Special Feature
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Reactive Burn Models for Detonation Propagation in High-Explosive Materials

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Computational studies of detonation in high-explosive (HE) materials at the macroscopic level typically employ grid-based numerical methods of hydromechanics where each material is treated as a homogeneous substance. For the HE, this requires equations of state for both the initial solid and final gas phases of the material (and some mixture rule for incompletely burned material), as well as a burn model that describes the rate of chemical reaction and energy release.

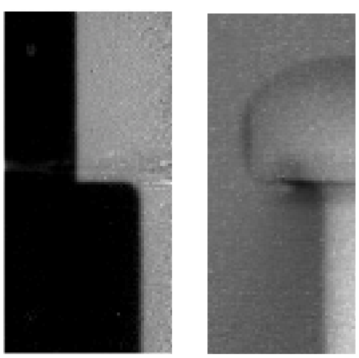
Most current burn models were calibrated with experimental data that was available 20 years ago, where this primarily consists of the knowing the positions of the shock / detonation fronts at particular points in time in an experiment. Much more detailed new data are being produced with recent advances in experimental technology, such as proton radiography (PRAD) and embedded electromagnetic particle velocity gauge techniques. These can supply information not only about the position of the shock fronts, but also can be analyzed for the density and velocity of the material behind the shock fronts. This allows us to more accurately evaluate existing HE burn models and quantify their weaknesses, and thereby develop improved models.

As an example, Figure 1 shows the results of a recent PRAD measurement on a corner-turning experiment. The initial density profile is shown at left where the HE will be initiated at the bottom. At right is shown the changes in the density profile shortly after the detonation wave has turned the corner. The darker region near the original position of the corner ("under the cap of the mushroom") is a denser region of incompletely-reacted HE. Six other snapshots of this same experiment at different times were also taken. The images have also been processed to give more quantitative density profile information.

Figure 2 shows the results from a calculation using the Multiple Shock Forest Fire model for a similar, though not identical, experiment. At left is shown the burn-fraction profile, where blue is unreacted material and red shows complete reaction. The finger of blue highlights the unreacted HE remaining from the corner turning process. At right is shown the pressure profile at the same time, where blue is 0 GPa and red is 40 GPa. The lower pressure at the end of the curl shows that the detonation has not yet been completely reestablished in the region beyond the corner.

Other experiments include the interactions of detonation waves with metals and other materials, and quantify their response to shock loading. This is an important information in improving constitutive models for those materials. However, results of those simulations will be limited by how accurately the initial HE response was represented.

Figure 1.



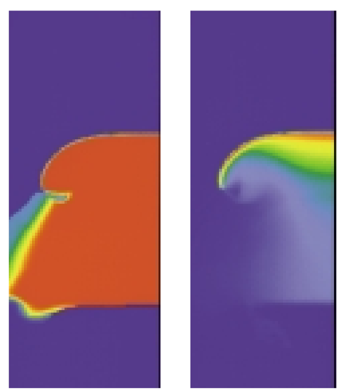


Figure 2.

Recent advances in experimental technology allow us to accurately evaluate existing HE burn models, identify their weaknesses, and develop improved models.

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